

ROAD REMOVAL TREATMENTS

FULL RECONTOURING

Full recontouring is the most complete form of road removal and is used where aesthetics are important or where reestablishment of subtle drainage patterns are important for slope stability. Full recontouring involves retrieving all of the embankment material and using it to fully match the pre-road landscape. By fully matching the natural landscape, subtle surface drainage patterns are restored. Full recontouring differs from other road treatments by completely matching the original landscape.



The dozer begins the excavation of the embankment by cutting down the outboard edge of the road at an angle. A berm left along the outboard edge holds soil in front of the blade and reduces loss downslope. Notice that the cutbench along the inboard remains intact as the dozer cuts.

Full recontouring begins by excavating all recoverable embankment fill. This process begins with the dozer cutting down the outboard edge of the road. During the first pass the dozer cuts an outsloped slot, leaving a berm right along the outboard edge of the road. The berm will hold material in front of the blade and reduce the amount of material that might be lost downslope. With each additional pass the dozer cuts deeper into the embankment and at more of a sideslope. At some point the dozer will either reach the original grade or the sideslope will be too steep to make another pass. At this point the dozer moves on to another

section of road and the excavator moves in to pull down the berm left by the dozer and recover the remaining embankment material. The dozer can either begin cutting a new section of road or can move back and begin the final shaping of the recontoured fill. The excavator continues recovering fill until the original grade is located. Once the excavator is finished recovering all of the embankment fill, it can move forward to continue brushing or excavating, or back to spread mulch on the finished surfaces. In some places where a narrow road is cut into a steep sideslope, the dozer cannot be used to cut down the outboard fill. In these situations, the excavator is used to recover all of the embankment fill.

Indicators of the original ground surface include layers of organic material, stumps, black or gray colored soil, stream gravel, and bedrock. As a general guide, the original surface can be estimated by standing back and looking at the surrounding landscape. Try to visualize the slope before the road was constructed. A clinometer can be used to measure the slope above and below the road to obtain an average. As the recontouring is proceeding, compare the recontour slope to your average hillside slope.

Most roads will have less fill available in the embankment than you need to make a full match along the cutbank. This is referred to as a fill deficit.

During road construction some material is lost down slope and is not recoverable. Also, during the life of a road, periodic maintenance and wear on the road surface results in a loss of material. Because most roads have a fill deficit it is essential to recover all of the road fill available to obtain a full match along the cutbank. If all fill is not recovered, there will not be enough material to match the surrounding grade. Borrow sites may have to be developed if not

enough fill exists in the embankment for full recontouring. Borrow sites are areas where the operator can remove soil without having any negative effect on surface flow. In some cases, inspectors may refer to a borrow site that needs to be recontoured. These borrow sites were constructed during the road construction phase and can have erosion problems. Material can also be imported from embankments where more soil exists than can be used to recontour the adjacent cutbank. In some cases, such as through-cut road segments where most of the original soil has been washed away, soil may need to be trucked into the site. Dump trucks may be used to move excess material when pushing with a dozer is no longer efficient.

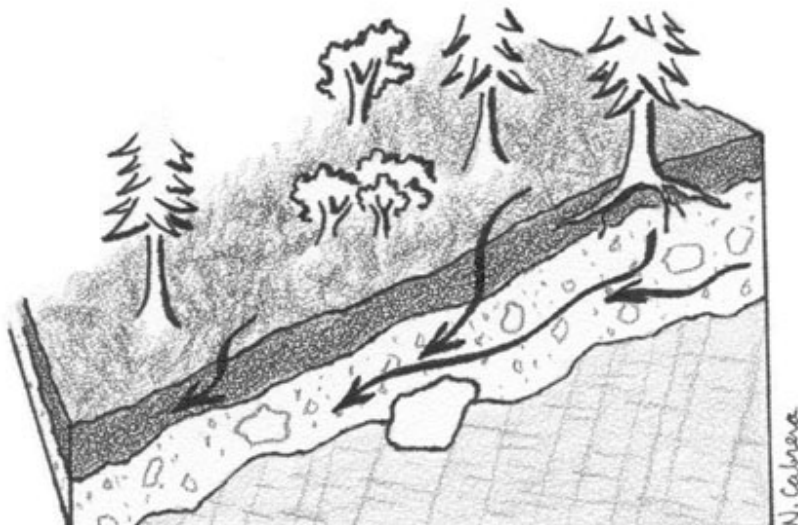


As the dozer cuts down the outboard material is pushed to the inboard against the cutbank. As the material is spread it is also compacted in lifts to increase stability of the recontoured slope. In the foreground the excavator places fill against the cutbank.

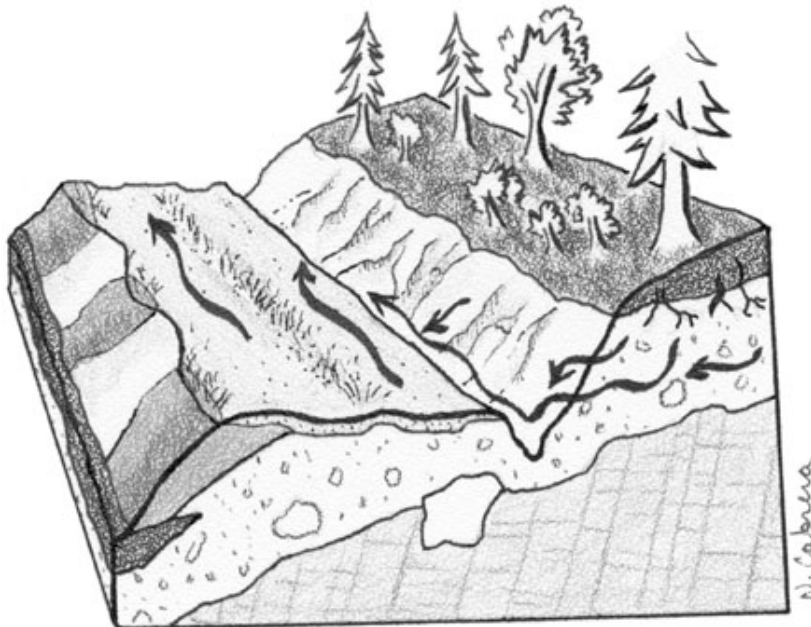


Once the dozer has recovered all of the outboard fill it can, the excavator moves in to finish the job. Reaching to the base of the embankment, the excavator recovers all of the remaining fill and places it in the cutbank.

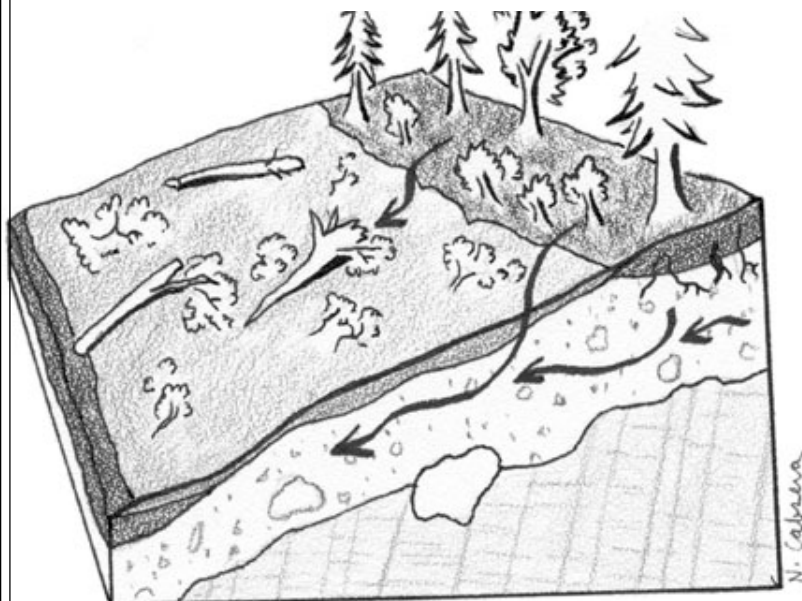
On larger roads, fill material is often out of reach of the excavator sitting on the existing road surface. To reach the bottom of the fill, the operator needs to “bench down.” Benching down, also called “ramping,” requires operators to cut a bench part way down the fill slope at an elevation that allows movement of equipment lower on the slope. Sitting on the bench, the operator excavates fill material



Natural, undisturbed slopes achieve equilibrated rates of erosion moderated by the vegetation and healthy topsoil. Before road construction and logging, this hill slope absorbed most rainfall and had little surface runoff that could cause erosion. The slope has developed natural runoff patterns and groundwater flows freely.



After road construction and removal of the vegetation, runoff patterns have been disturbed and erosion rates increase. The compacted road surface collects water and concentrates it on unstable locations, such as over the embankment. Groundwater flow daylights in the cutslope and flows down the inboard ditch. These water concentrations allow the runoff to build enough energy to cause erosion and sediment problems.



After road removal, the slope is returned to a near natural condition. The natural contours have been returned to the slope to allow free flow of surface runoff and to increase groundwater flow. Trees and brush have been placed on the soil surface as a mulch to protect against erosion from raindrop impact and sheet flow. A topographic match to the surrounding slopes has been obtained by the equipment operators working on this site.



Benching down is a technique used by operators to reach fill material that is out of reach from the road surface. The dozer or excavator constructs a small bench part way down the slope where the excavator can safely sit and reach the bottom of the excavation. Once in position, the excavator places material up on the road surface where the dozer can push it away from the site against the cutbank. (Left courtesy RNP, right courtesy RCAA)

and places it in an area where the dozer can get a good push. Benching down is also used for excavating stream crossings where large fills are present.

MATCHING THE CUTBANK

As material is excavated from the embankment, it is moved into the cutbank where it is shaped to match the surrounding topography. The first few lifts of material spread and compacted along the inboard are used to fill and seal any inboard ditch that may exist. Wherever possible the dozer is used to push fill material into the cutbank, compacting it in lifts. If an excavator is being used to place fill, it should also provide some compaction to recontoured fill. This can be done with the bucket, but it is time consuming and expensive. The excavator can be used to track back and forth across the material, but caution should be used if the slopes are steep. Fill is spread and compacted in lifts against the cutbank until a full match is achieved.

THROUGH-CUT RECONTOURING

Through-cut road segments are common and require special treatment. Through-cuts require importation of material from nearby road embankments (typically downhill) or terraforming (see next section). As material is spread and compacted in lifts, the through-cut is filled to match the cutbanks on both sides. Once the through-cut is filled, the surface must be shaped so that runoff drains away from the recontoured



Full recontouring of a legacy road was prescribed to rehabilitate this prairie. Full recontouring is often applied to roads on prairies and at other locations where visual aesthetics are important.

A SIX STEP EXAMPLE OF ROAD REMOVAL TECHNIQUES



Road removal prescriptions are based on site specific conditions. 1) Starting in foreground, a road was constructed through forested terrain using a cut and fill approach. 2) A roadway after years of use including development of tire ruts, rills, and an outboard berm. 3) The beginning of the road removal process where a dozer has ripped the road. 4) The development of an outslope constructed by a dozer pushing material from the outboard edge of the road up against the cutbank, retaining a berm to limit sidecast. 5) Recontouring work as it nears completion. This stage is usually done with an excavator which pulls the berm left by the dozer and begins the final shaping. 6) The final recontour with a full match to the existing slope.

area. This is very important! If the throughcut is not completely filled and shaped to pass runoff, it will rapidly erode the loose fill and deliver it downslope or into adjacent streams. Where through-cuts run directly downhill, crown the top of the recontour so runoff flows away from the recontoured fill. Where through-cuts run across the slope shape the surface to promote uniform sheet flow. Do not forget to account for some settling!



As the dozer nears the top of the cutbank, the fill material is compacted and blended with the slope above. On full recontouring jobs, the fill should be pushed up to completely cover the cutbank.

When through-cuts are cut into steep slopes and run directly downslope, recontouring them is risky. Loose

fill piled in the cut is prone to saturation and failure. The risk of post-treatment failure can be reduced by completely eliminating runoff onto the treated through-cut. Never recontour through-cuts that have springs or seeps in them. They are best left untreated.

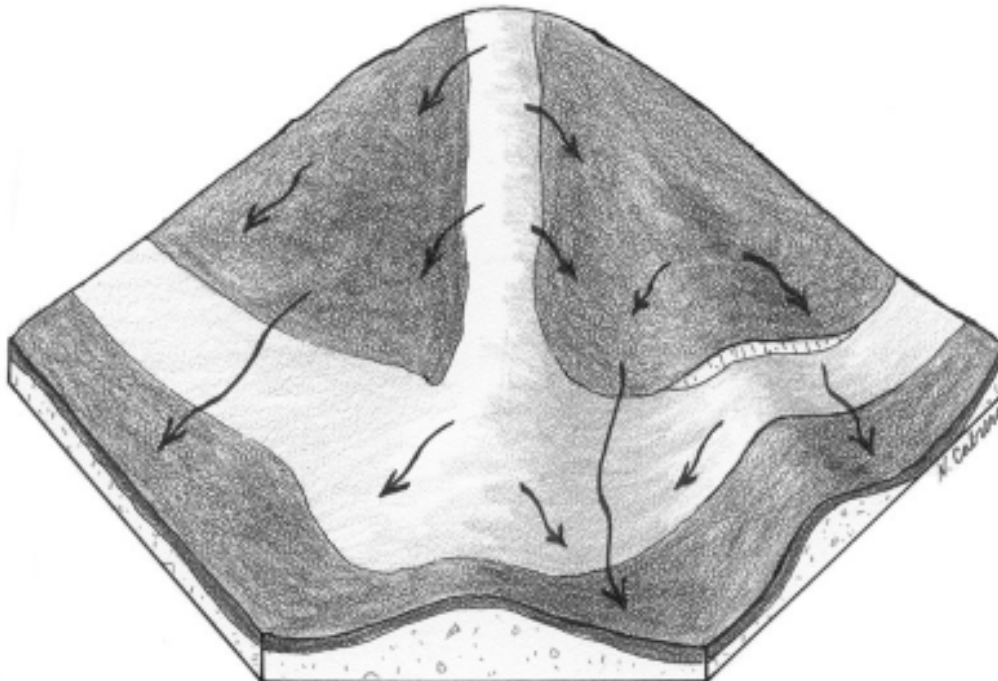
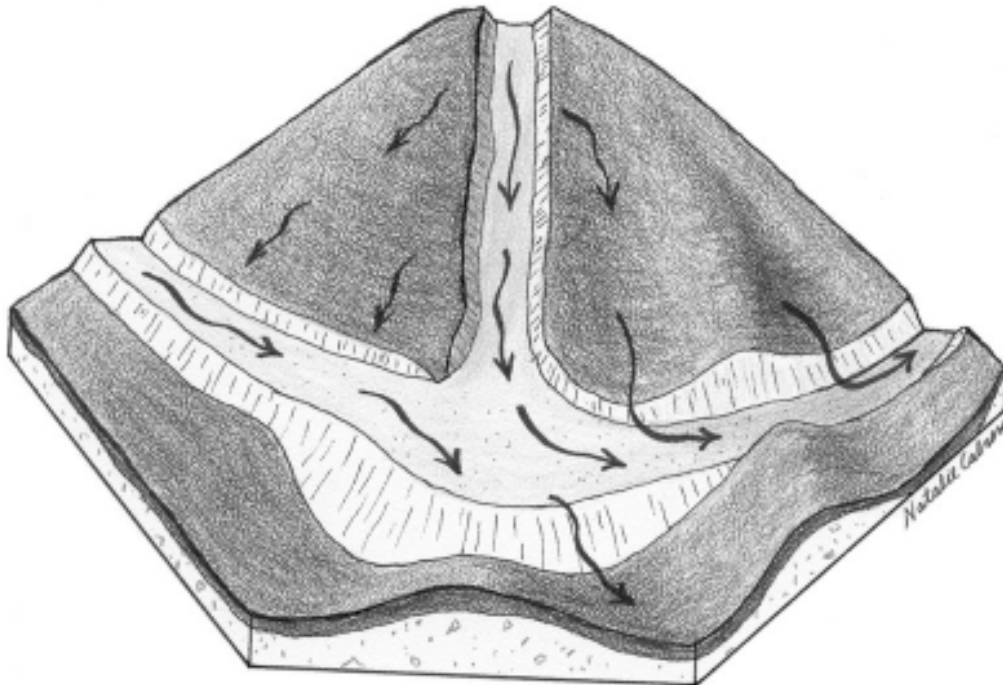
TERRAFORMING

Terraforming is the practice of recontouring the landscape at sites where past disturbance has made it impossible to restore the natural runoff patterns by simply removing a road or crossing. Terraforming is used as a last resort in locations where a no treatment option would result in the continued damage to the landscape. Fill material is “borrowed” from surrounding areas and used for recontouring.



Through-cuts require importation of material from nearby road embankments or landings. As material is spread and compacted in lifts, the through-cut is filled to match the cutbanks on both sides. Once the through-cut is filled, the surface must be shaped so that runoff drains away from the recontoured area. Left, road through-cut on a ridge top prairie. Right, road after recontouring.

THROUGH-CUT RECONTOURING Before and After



Through-cut recontouring can be a difficult part of many road rehabilitation projects. Often a road has been constructed straight down a ridge or has been cut through a ridge while traversing a slope. These roads cause a large disturbance to natural runoff patterns. To recontour a road dropping straight down a slope, push fill up from a landing or road where the material was pushed during road construction. If additional material is needed, pull material in from the sides and crown the old road centerline. Be sure water drains away from the road and not down it.



Terraforming is commonly used to recontour through-cuts where the original material has been washed away. Fill material is borrowed from the top of the cutbanks which are lowered until the fill and the cutbanks match. Terraforming is also used when reshaping areas that have been severely altered by gullies or deposits of material from floods or landslides. After diversions are removed and runoff patterns restored, gullies no longer carry diverted water. Gullies can then be filled with compacted material, smoothed out, and shaped into a natural looking slope.



Because recontouring and terraforming match the surrounding terrain, the two treatments are generally the best for reestablishing subtle slope drainage and stream flow. The two treatments are also used when roads are near visitor use areas and other publicly visible locations with high aesthetic value.

ROAD DECOMMISSIONING



Road decommissioning is often prescribed for roads that are no longer needed but that may be reopened at some later time. Decommissioning for these types of roads is preferred over full recontouring because much less material is used to outslope the road and reconstructing the road in the future is faster, safer, and less costly. This technique can also be used to permanently treat roads where a small budget prevents full road recontouring. Road decommissioning is also called “outsloping” or “partial recontouring.” Decommissioning consists of three main components: outsloping the roadbed, removing stream crossings, and recovering any unstable embankment fill.

Terraforming can be used to shape an area and blend it in to the natural environment where severe erosion has permanently altered the natural runoff pattern. In this sequence a deep gully is eliminated and the natural drainage pattern is restored.

Road decommissioning is not as effective as full recontouring for restoring the subtle natural runoff patterns to a hillslope. In addition, fill material left in the embankment can become unstable over time and fail downslope. Exposed cutbanks left behind during a partial recontour can lead to landsliding and collapse from the slope above the road. On the other hand, decommissioning is less expensive and allows for more miles of road to be treated per dollar than a full recontour. Decommissioning is also good because it leaves a partial roadbed intact for emergency fire road construction. Road decommissioning is often used on private land where timber companies plan to access a harvest unit in the future.



Road decommissioning is the partial removal and outslowing of a road to improve natural drainage where the road may be rebuilt sometime in the future. Decommissioning includes crossing removal, unstable or perched fill removal, and

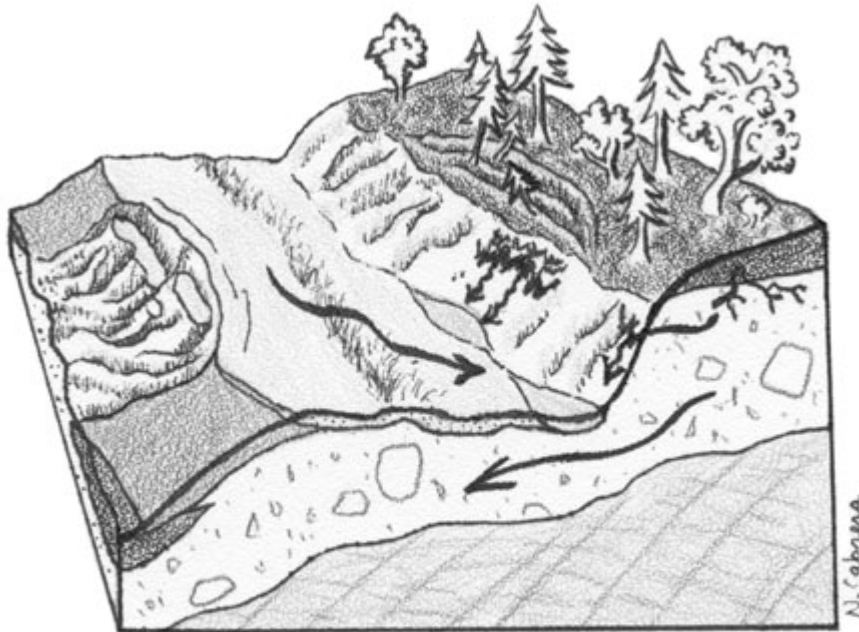
Construction of a road outslope during decommissioning involves the same process as full recontouring but stops short of matching the cutbank. Instead the recontouring is completed when enough outslope has been put on the roadbed to convey runoff across the road without running down it. The outslope needs to be at a steeper angle than the road grade. The steeper the road, the steeper the outslope that is needed.



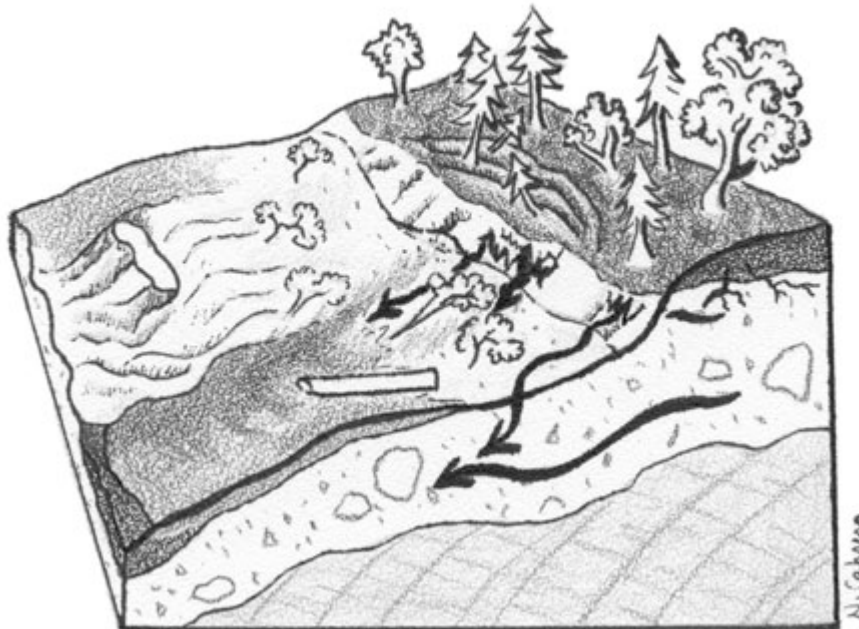
The main activity in road decommissioning is the removal of stream crossing fill material and any culverts or Humboldt crossing logs. Decommissioning can occur with a single piece of equipment if the majority of the road bench is to remain in place. (Courtesy RCAA)

During outslowing, any unstable or perched fill is removed and placed in a stable location. Stream crossing fill is removed and placed against nearby cutbanks. Small swales or depressions are recontoured to reestablish drainage patterns. All recontoured material should be compacted in lifts to improve stability. Rolling dips are constructed at intervals to ensure flow does not run down the decommissioned road. Rolling dips are required where

ROAD DECOMMISSIONING

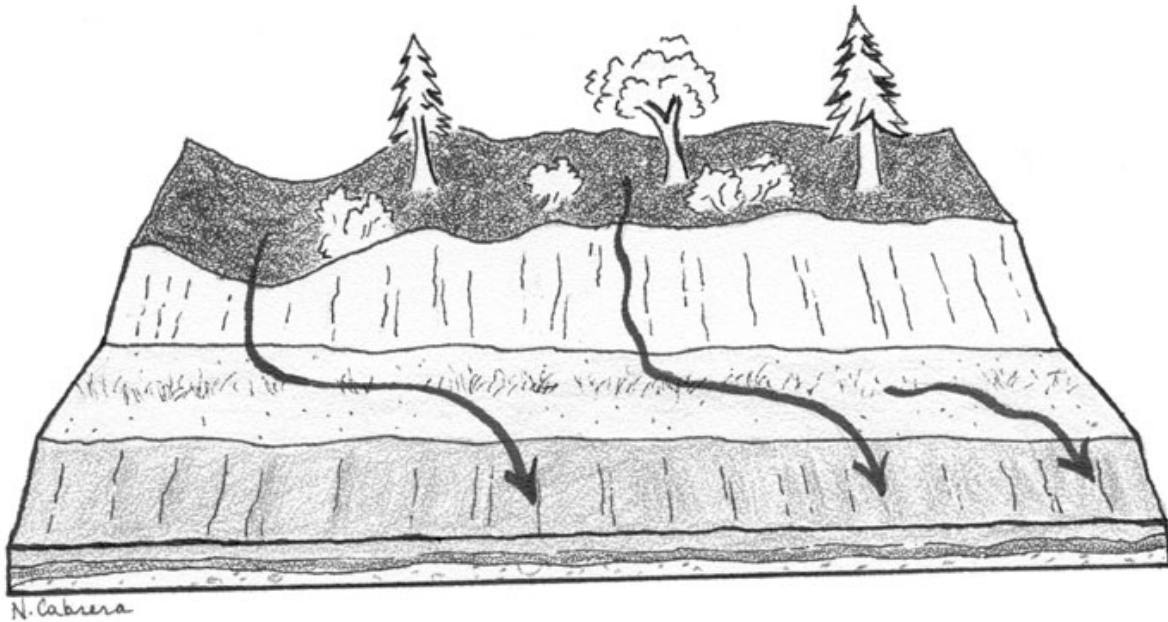


Fill slope failures are a common problem on many backcountry roads. If the roads are constructed adjacent to a stream, these failures can contribute sediment directly into a stream. Sometimes these failures can trigger a larger hillslope failure as the material moves down a steep slope. In some cases, these failures are caused by springs or seeps that exist along the road. In the case of cutbank seepage, outsloping or partial recontouring would be prescribed.

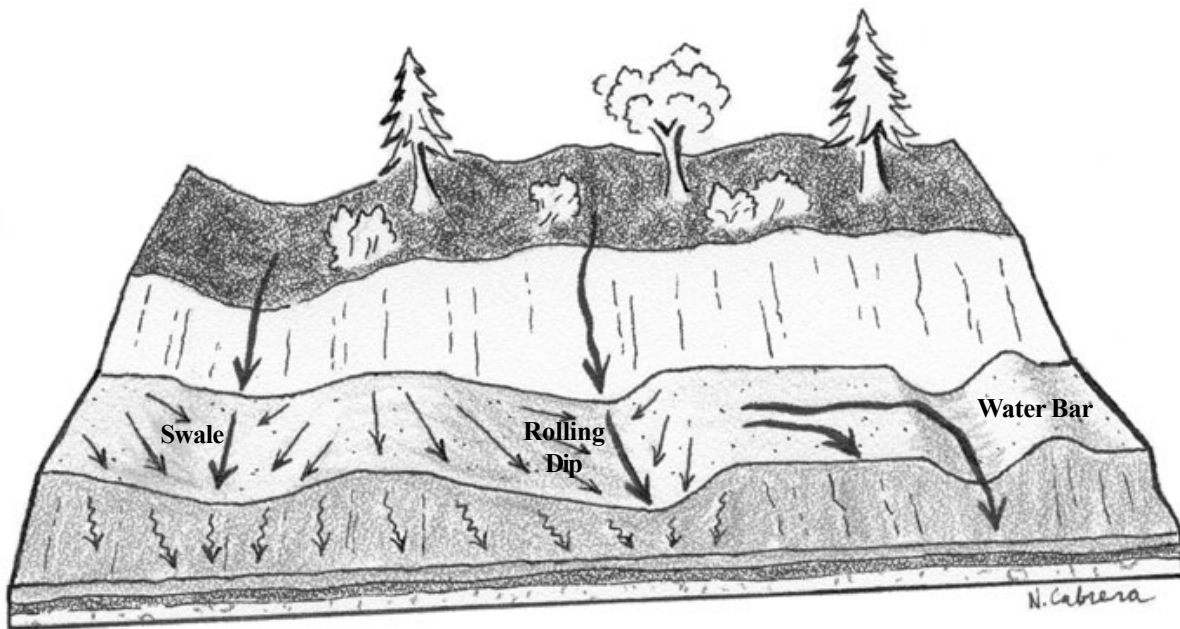


Road outsloping or partial recontouring provides drainage to the road surface but does not place recontoured fill high up against the cutbank where it may be destabilized by buried springs or seeps. In partial recontouring, unstable fill is removed from the outside edge of the road and placed away from springs or areas that have a potential for landsliding.

WATER BARS AND ROLLING DIPS



Poorly constructed roads can collect water from small natural swales and divert it down the road to unstable locations. Runoff from slopes and the road surface can concentrate flow down the road causing rills, gullies, and landslides. Roads without proper drainage cause erosion and sediment problems across the landscape.



Road decommissioning includes construction of swales, rolling dips, and waterbars. Swales are constructed where a road crosses a natural topographic swale or ephemeral stream channel. A swale is an outsloped depression that drains water freely across the road. Rolling dips are similar to a swale, except they are usually used on roads with a steeper grade and are used to drain cutslope and road bed runoff. Rolling dips are designed so vehicles can easily travel across them. Rolling dips are placed where stable features exist that can carry runoff without causing erosion. Waterbars are abrupt ditches cut across the road with a berm piled up on the down slope side. They are easily damaged by motorized traffic, expose material to surface erosion, and should not be considered a long term solution to road drainage problems.

outsloping cannot effectively direct sheet drainage off of the road. Every effort should be taken to locate these dips where natural drainage swales already exist downslope.

Road decommissioning is usually carried out with an excavator and a dozer with a six-way blade. As with full recontouring, the dozer makes the first pass, ripping the inboard ditch, rills, and gullies. The dozer then begins pushing fill from the outboard edge of the road toward the cut-bank. The dozer also

begins dishing out crossings as they are encountered. The excavator then makes a pass removing any unstable fill from the embankment and removing stream crossing material not accessible to the dozer. The dozer completes the earthmoving work by compacting and grading the finished surface. The last step is to mulch the site using the excavator to spread material stockpiled during the initial brushing.



Road sections are outsloped during road decommissioning to eliminate runoff interception and accumulation on road surfaces. At this site, the excavator was retrieving embankment fill perched along the outer edge of a small landing. The dozer (background) will spread the fill along the inboard edge of the road creating an outslope.

FINISH GRADING

The final earthmoving task of both full recontour or decommissioning is finish grading. The purpose of finish grading is to eliminate berms or depressions on the fill that can collect runoff and cause gulying or failure. This is especially important where the recontoured fill meets the original slope above. As fill is placed against the cutbank, small berms and gaps often remain at the top of fill. These ridges or depressions collect slope runoff and concentrate runoff into the newly recontoured fills. Be sure that the interface between the natural slope and the recontoured fill is smooth and free of any ridges or depressions.

This step is done with either the dozer back-blading the slopes or by the excavator using a straight log or wad of brush pinched in the bucket. Small windrows usually remain after this step but they are eliminated when the excavator spreads mulch on the finished surfaces. Be sure you are satisfied with your finish grade before you mulch. Removing mulch to change the shape of the recontoured fill is very time consuming and does not produce good results.

MULCHING

Once the final shape has been achieved, the excavator places previously removed trees and brush on top of the recontoured fill. Woody material is spread evenly over the newly recontoured slope. Tamping woody material down onto the ground provides contact with the soil reducing sheet erosion. Large clumps of brush should be pulled apart and spread whenever possible. Large tree trunks should be laid perpendicular to the slope to break up surface runoff and catch fine sediment. Logs laying perpendicular to the slope should be

punched into the soil or keyed in behind something to keep them from rolling down the slope. In coastal climates, the use of straw mulch is not necessary and may actually slow down natural revegetation. In climates with a hot, dry season where natural revegetation is much slower and onsite organic material is limited, a weed free straw mulch will help retain soil moisture, promote seed germination and reduce surface erosion.



One final step before the mulch is applied. The excavator works along the top of the cutbank eliminating berms and depressions where fill meets the original slope. If these pockets are not blended to the surrounding slope runoff may accumulate and cause a fill failure.

ROAD-TO-TRAIL CONVERSION

Road-to-trail conversion is a technique used for transforming an existing road into a recreational trail. Similar to road removal, road-to-trail conversion involves excavating road fill from the embankment and placing it against the cutbank to match the slope above. However, the trail conversion requires leaving a 5- to 6-foot-wide portion of the original road bench to serve as the new trail tread. The trail bench should be located on the cutbench portion of the old roadbed, not on embankment material.

A common mistake in road-to-trail conversion is building a new trailbed on recently recontoured fill. Using that technique, the road is fully recontoured and then the excavator re-excavates or tamps in a new trail tread. Reconstructing a trail in loose fill causes severe settling problems on the trail tread and oversteepens



Brush and trees that were removed from the road alignment at the start of road removal should be placed on the final surface as mulch. As the excavator moves down the road, stockpiles of mulch above the cutbank are spread. Be sure to tamp material down so it is in contact with the soil to help the material decompose rapidly and help reduce fire hazard.

the cutbank resulting in post-treatment failures and high maintenance cost. Instead, the trail tread should be preserved as a portion of the original roadbed. This results in the trailbed being located on a solid, well-graded surface that can withstand recreational foot traffic.

Another common mistake is to convert a poorly designed road into a poorly designed trail. Road-to-trail conversion should only be applied where proper trail design criteria can be met. A successful

conversion requires that the road be located on stable ground and have an gentle curvilinear alignment consistent with proper trail layout. Roads that are excessively steep, located on ridgetops or flats, and roads cut into unstable terrain are all poor candidates for conversion. In these situations, it is best to remove the road and reroute the trail to a more suitable alignment.

Unlike back-country road removal projects, road-to-trail projects are highly visible to the public. The visual impact of a recently completed conversion can be softened with some handwork to cut up and spread larger woody debris. Plantings of native vegetation can also speed recovery of the site following conversion.



Road-to-trail projects involve converting unwanted roads into recreational trails. The process is similar to road removal, but the equipment maneuvers are more complex because a portion of the original road bench must be preserved for use as the trailbed. Here an excavator is depositing fill in the cutbank while straddling the trail bench (visible in the foreground).



Road-to-trail conversion includes complete excavation of stream crossing fill material. Some crossings will have a foot bridge constructed across the drainage which allows the approaches to remain elevated above the stream. At other sites, handcrews construct the crossing approaches and low-water crossings through the stream. Left: heavy equipment working in tandem to remove a landing adjacent to an active stream. Right: the same site after a Road-to-trail conversion. The new trail alignment dips into stream crossings, maintains a gentle grade and is outsloped to provide drainage. (Courtesy of Salix)

THE CONVERSION PROCESS

Proper trail layout requires training and experience in trail design, construction techniques, and watershed processes. Be sure to include a trail expert on your planning team for road-to-trail projects. This will ensure your conversion project will pay off with a well-built, sustainable trail.

Depending on the surrounding terrain and the original construction of the road, the trail alignment may meander across the road surface. Where swales intersect the road, the cutbank usually disappears so the trail tread should meander all the way to the inboard edge of the road. Likewise, where springs exist, the trail should meander to the inboard. Where large trees are growing through the embankment fill, the trail can meander to the outboard edge of the road. By meandering the trail, a visually stark, straight road section can be converted into a pleasing pathway through the forest. Meanders can also help reduce steep grades along the alignment by increasing the running length of the trail.

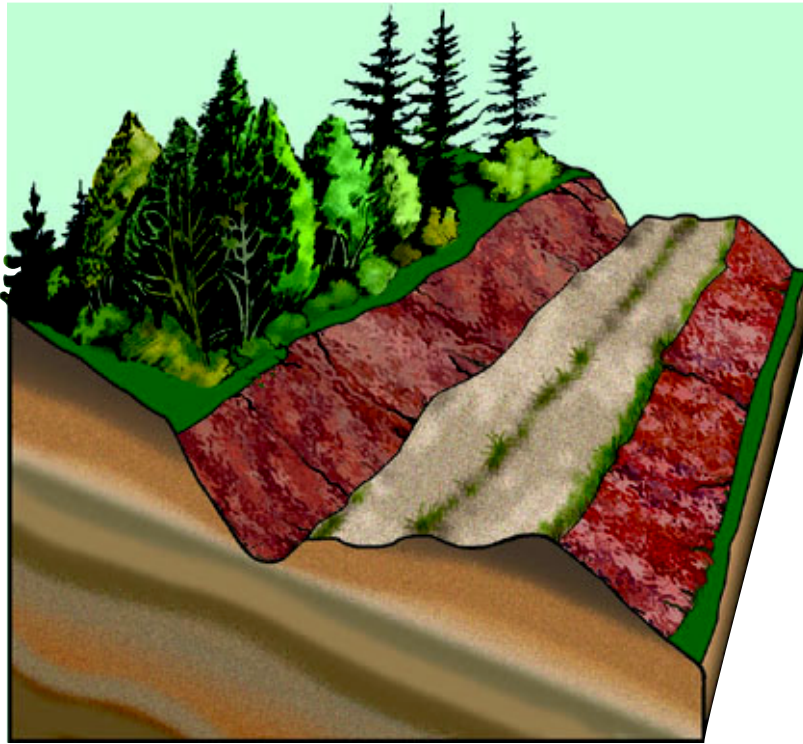
Prior to excavation work the inspector will identify the location of the trail tread on the road surface with marking paint or pin flags. The markings consist of two lines, one indicating the inboard edge of the trail and one the outboard edge.

Once the trail marks are finished, the dozer begins by ripping the sections of the road that are not marked as trail. When the ripping is done, the dozer begins cutting down the outboard edge in much the same way as for recontouring. However, the outboard trail marking is the limit of the excavation. No material should be excavated inboard of the outboard mark. The first few pushes from the dozer are used to cover the trail tread in 6 to 8 inches of spoils to protect the surface from damage. Once covered the dozer can continue to push material across the trail and into the cutbank, out as far as the inboard trail markings. When the dozer has pushed all it can, the excavator comes in and pulls the remaining embankment, placing the fill along the inboard side of the trail. Wherever possible the dozer should compact and shape the inboard fill. The last step is for the excavator to spread brush and mulch on the finished surfaces on both sides of the trail. When the excavation is finished, the trail remains buried under the spoils originally spread on by the dozer. This material will be removed during the final shaping by a trail dozer or a handcrew.



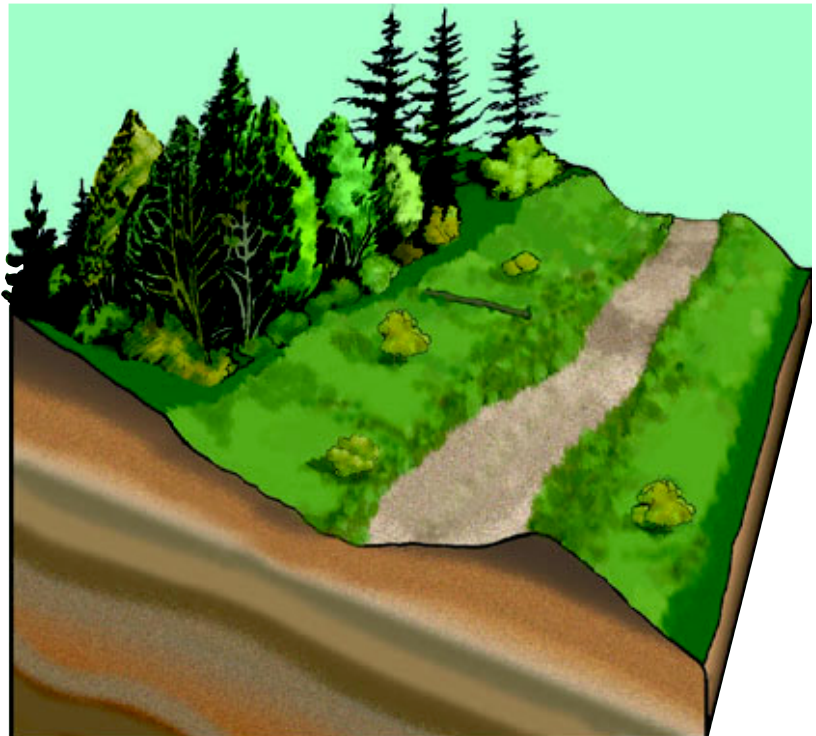
Trail dozer compacting the fill slope on a road-to-trail conversion project. After fill compaction, the dozer back-draws the trail surface to remove loose material and provide an outslope for proper trail drainage.

ROAD TO TRAIL CONVERSION



Many trails within State Parks are developed on legacy roads that were constructed before the area became public land. Early park managers found it was much easier to let a road close in with vegetation and become a trail, than to construct a new trail. Where roads did not connect, short trail segments were often built to link the roads into a trail network. Unfortunately, poorly constructed roads make poor trails. Grades are often excessive, and many of these roads continue to be sources of sediment and erosion problems. Roads that are unsuitable as trails are removed by full recontouring or decommissioning. Where roads do provide a suitable trail alignment, the road can be converted to a trail. Conversion greatly reduces erosion problems and provides park visitors with a more pleasant hiking experience.

A road-to-trail conversion transforms an existing road into a recreational trail using heavy equipment. The process begins by removing encroaching vegetation from the roadway and stockpiling it nearby. Then the dozer rips the inboard ditch and inboard road surface to reduce ditch memory and increase the permeability of the roadbed. Once the roadbed is prepared, embankment fill is excavated from the outboard edge of the road and placed against the cutbank. Between the excavated fill and the cutbank fill, a 5-foot wide portion of the original road is preserved and will serve as the trail tread. The trail should be located on the cutbench of the road, not on the embankment fill. This ensures the trail is on stable well-compacted material. The trail can be constructed with gentle meanders to soften the appearance of a straight road section.



SHAPING AND MULCHING THE TRAIL

Shaping the trail surface includes removing the protective soil spread on by the dozer during the excavation work and outsloping the trail tread to provide sheet drainage. A small trail dozer is commonly used to clear and shape the trail surface. However, if a dozer is not available, handcrews can usually make quick work of the shaping.

Mulching involves cutting and spreading brush and mulch left by the excavator along both sides of the trail. The excavator is not efficient at sorting and spreading mulch and brush used to finish the work surfaces. Instead, the excavator can place the brush in position leaving the fine tuning to handcrews. Handcrews cut the material into smaller pieces then spread it evenly on the exposed surfaces. In especially sensitive areas, crews can be used to transplant native plants into the recontoured fills to soften the appearance and speed revegetation.

STREAM CROSSINGS ON ROAD-TO-TRAIL CONVERSIONS

When converting a road to trail, road stream crossings are completely removed (see next section) and replaced with a trail stream crossing. Trail crossings are designed to provide safe passage for users while improving water quality and protecting the riparian and aquatic habitats along the stream. Because trails follow a curvilinear alignment, crossings are not required, and in most cases can be replaced by simple low-water crossings that conform to the stream channel profile.



Road-to-trail conversion projects are highly visible to the public. These road-to-trail sites have already started recovering with natural revegetation less than one year after conversion.

Constructing a trail through a stream crossing is similar to the treatment at swales. As the equipment approaches the crossing, the trail should meander to the inboard edge of the road and descend toward the stream. This will maintain a curvilinear alignment through the crossing and eliminate any diversion potential along the trail. In most cases, the heavy equipment can complete the trail approach as part of the crossing excavation, but where the trail intersects the stream, the heavy equipment work is complete. Once the heavy equipment is safely away from the crossing site, a suitable trail structure such as a bridge or a rock armored low-water crossing is constructed by hand.

ROAD STREAM CROSSING REMOVAL

Road stream crossings are located wherever a road crosses a stream channel. Although they can be found anywhere on the landscape, crossings are often concentrated along the lower and middle segments of the slope where streams are more numerous. Stream crossing removal involves excavating crossing fill, culverts, logs, and other debris from stream channels. The material is moved away from the crossing and deposited in stable sites to prevent crossing failure and soil delivery directly into streams. Crossing removal restores streams to their original course and grade. Crossing removal also hydrologically disconnects roads from the drainage system, preventing diversion of the stream flow down road surfaces.

Stream crossing removal includes removal of Humboldt crossings. Built by placing logs into the stream channel and then pushing fill over them with a dozer, Humboldt crossings pose the gravest threat to aquatic and riparian habitats. These crossings can plug easily during high flows and catastrophically fail or divert runoff onto adjacent road surfaces. Stream crossing excavations also include removing culverts, pipe arches, or log bridges, that will eventually fail if not maintained. In some cases, roads were constructed across stream channels without any drainage structure, leaving the flow to cross directly over the road surface.

The best time to remove crossings is during late summer months when stream channels are flowing slowly (wet) or dry. If the stream is flowing, it can be temporarily diverted around the site using a small coffer dam and flexible pipe. Temporary diversions help keep the work area dry and prevent sediment from moving downstream during construction. This also helps protect fish and other aquatic species. To prevent pooling and catastrophic failure, removal of wet crossings must always begin at the downstream end of the site. In dry crossings



The excavator works to locate the natural stream bottom indicated by bedrock, rounded boulders or cobble, buried stumps or a layer of buried organic topsoil. The machine usually begins at the downstream end of the crossing to prevent upstream ponding of any flow that might be moving through the crossing. (Courtesy of RCAA)



Stream crossing removal reduces the potential for water to divert down the road, eliminates the potential for fill failure during large storms and improves conditions for fish migration upstream. (Courtesy of RCAA)

the excavation can start at either end. However, unexpected rainfall and runoff before the crossing excavation is complete can lead to disaster.

MATCHING THE GRADE

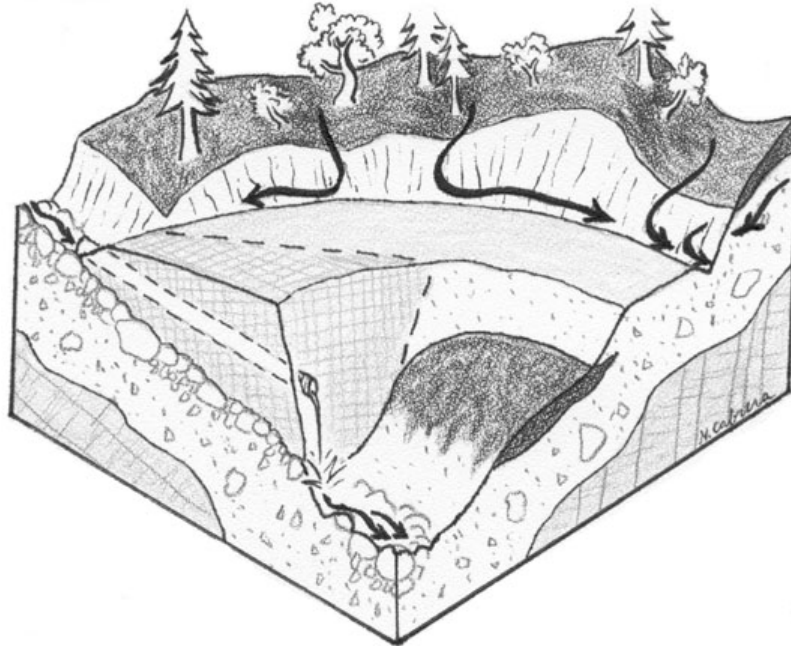
As with other recontouring efforts, the first task is to remove the trees and brush from the fill material. Because thorough mulching is necessary on all stream crossings, the material should be stockpiled nearby for later retrieval. Once the brushing is finished, the dozer begins by dishing out as much material as possible. The dozer pushes soil in both directions away from the center of the crossing and places it along adjacent road sections. The soil is compacted in 6-inch lifts against the cutbank. Avoid placing fill against the cutbank immediately adjacent to crossings. Instead, push it as far away from the crossing as possible. As the dozer dishes down into the crossing, the banks become steeper. When the hole becomes too steep and the dozer can no longer push out of the crossing, the excavator moves in to finish the job. The excavator can reach deep into the crossing and place soil upslope where the dozer can continue to push it away.

In some cases where no stable sites exist adjacent to the crossing, fill is trucked away to a remote site away from drainages or concentrated surface runoff. In these situations, the excavator loads the dump trucks directly from the crossing or from a pile pushed up from the crossing by the dozer. When planning an end-haul excavation, it is important to leave a good road into the site for the trucks until the last of the fill is excavated. If you cut off your access too soon, the excavator may have to move the same soil several times to get it all the way out of the channel.

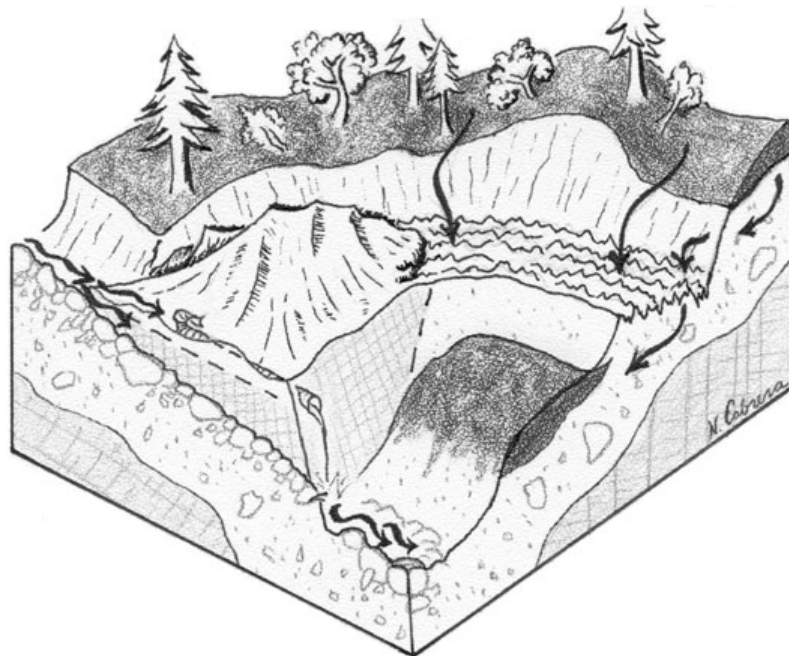
During stream crossing removal, the operator works to remove all crossing fill and locate the natural stream banks. Natural indicators such as large woody debris, rounded gravel, cobble or boulders, dark organic soil and bedrock are usually reliable indicators of the original stream bed and banks. When excavating crossings also look for buried stumps that indicate the natural slopes adjacent to the stream. It is also useful to examine the banks upstream and downstream to get a feel for the natural shape. If natural stream banks are difficult to locate lay the banks back as much as possible to create a gentle slope close to the stream.

STREAM CROSSING REMOVAL

Before and during



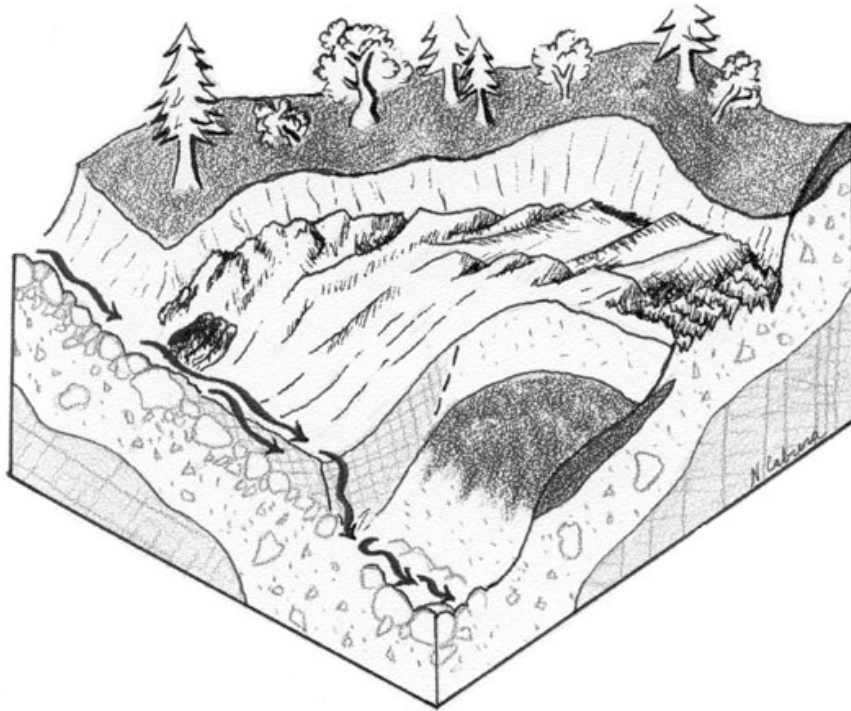
Stream crossings are a large source of erosion and sediment problems across the landscape. Due to current failure, stream crossing fill can easily enter the watercourse. Road drainage structures such as the inside ditch are also problematic at stream crossings. Crossing excavations should preferably take place during summer no-flow periods or use a temporary diversion.



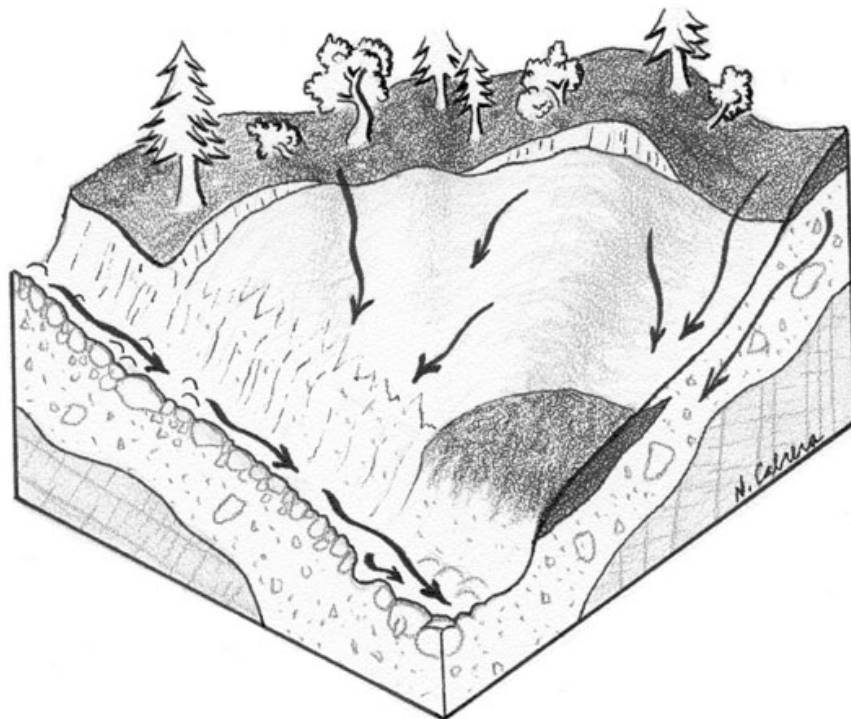
After ripping the road surface and inboard ditch, the dozer begins to dish out the fill material above the culvert. This material is pushed away from the crossing to adjacent road sections and used for recontouring. By moving the fill away from the crossing, it ensures that if any failures occur they will not deliver sediment into the stream course.

STREAM CROSSING REMOVAL

During and After



After dishing out, the excavator removes the culvert. Once the culvert is gone, the excavator shapes the stream crossing by attempting to uncover the natural channel banks and adjacent slopes.



After complete stream crossing removal, the drainage is returned to its predisturbance topography. Natural drainage patterns are returned, and the potential for road failure is eliminated.



Stream crossing removal requires that equipment work on steep and sometimes unstable slopes. Operators frequently need to reposition equipment and move dirt twice to excavate complex crossings. Buried logs, stumps, and culverts can require an unexpected change in plans as the excavation proceeds. (Courtesy of RCAA)

The stream gradient through an excavated crossing is typically a constant slope from the upper to lower control points. On high-gradient streams, the channel should follow its original course through the excavation and not have sharp meanders or bends. The stream channel should follow the fall-line and run directly down the slope. On a low-gradient meandering stream, try to locate and match the bends and turns of the natural channel. Preserve natural nick-points in the streambed such as bedrock or large woody debris to help protect against gully formation. The finished stream channel should be free of large rock and woody debris. Although natural, these obstructions will divert flow into the soft banks of the crossing. Scour along the banks of the crossing can lead to slope failure and delivery of sediment directly into the stream. Natural recruitment of large rock and woody debris will occur with time, giving the soft bank material a chance to harden and revegetate.

FINISH GRADING AND MULCHING

The last steps of a stream crossing excavation are finish grading and mulching. As with road removal, the slopes adjacent to the crossing should be graded to eliminate any remaining windrows that may concentrate runoff causing rills or gullies. Because completed crossing slopes are often steep, the dozer cannot accomplish this task. Instead, the excavator can use the thumb to grip a log or bundle of brush and use it to finish the slope.



Photo on left shows an excavator removing part of a culvert on a large stream crossing (Courtesy RNP). Photo on right shows an excavator starting to remove a culvert after the dozer has completed the first dishing out (Courtesy RCAA). Springs and seeps can be treated like a small stream crossing by excavating out a swale to allow free draining of water.



Stream crossing removal involves maneuvering the excavator into difficult locations in order to reach all the road fill. In this case, the excavator uses the bucket to support the machine as it moves down a steep slope. (Courtesy of RCAA)

Stream banks and roads adjacent to streams should be thoroughly mulched with organic material. Organic material reduces rainsplash erosion, traps sediment, reduces rilling, and provides shade for emerging vegeta-

tion. Stockpiles of organic material should be available from brushing that occurred before the earthmoving work began. The excavator typically spreads the mulch because it is far more effective than the dozer, although the dozer can be used to push large piles of brush to the excavator for spreading.



A thick layer of mulch is important on the slopes of stream crossing excavations. Trees and brush, cleared from the crossing fills before earthmoving work, are spread uniformly on the slope. Notice that woody debris has not been placed in the channel. Debris placed in the channel can divert flow into the soft banks of newly excavated crossings causing shallow landsliding into the stream.

SPRINGS AND SEEPS

Springs and seeps require a separate discussion due to their special treatment in road removal projects. Springs and seeps can appear anywhere on the landscape. Some are seasonal, some perennial.



Springs should remain free draining and not covered with dirt. At springs, the fill slope on the outside edge of the road should be removed and placed against the cutbank away from the spring. However, at this site springs were buried by recontoured fill which resulted in a failure.

Indicators of springs and seeps include water-loving plants like ferns and rushes, and gray or black soil color. Fortunately, flowing springs and seeps are readily identifiable along roads where vegetation and duff are sparse. However, seasonal springs may dry up in the summer and fall and can be overlooked. Be sure to survey for springs and seeps in the winter and spring when they are flowing and flag them for summer work.

Where springs are located, do not bury them under recontoured fill material. Recontoured fill can become oversaturated with groundwater and fail. Springs should remain free draining and be reconnected to the drainage network if swales or streams lie downslope. Where springs are encountered, the embankment should be completely removed and a broad swale should be developed across the road to convey spring flow. Inboard ditches should be eliminated where spring flow emanates. They can either be filled with compacted material or a cross draining swale can be cut to the level of the ditch bottom. On road-to-trail conversions the trail should meander into the cutbank and a rolling dip should be cut at the spring location.

PROTECTING THE LANDSCAPE

While working on road removal projects, be careful to avoid damaging the surrounding landscape. Trees, stream channels, archeological sites, and other sensitive areas can be impacted either directly or indirectly from road removal work. Be aware of potential hazards inside and outside of the work area as the project proceeds. Also, take into consideration the effect that the project might have on surrounding areas after the work is complete. Are the fills stable? Are all the remaining trees sound? Is the stream channel stable? These are some of the questions you might ask yourself as the project proceeds.

When pushing over trees that are growing within the excavation boundaries, use caution to prevent them from falling into and damaging nearby trees outside the work area. Take extra care to avoid striking old growth and special status trees as tree bark and tissue are



Protecting trees is especially important in park settings. Avoid striking trees with the bucket or dozer blade, and avoid digging up their roots.



Historical structures on State Park property, such as this old logger cabin, are valuable cultural resources that must be protected. On most projects, historical objects will be identified prior to construction, however, if you discover additional historical sites, stop work and notify the project inspector.

of erosion in the event of a surprise fall rainstorm. Do not begin excavations that cannot be closed within one day as wet weather approaches and do not work in rainy weather. Following moderate or heavy rain, allow at least two days for soils to dry out before resuming work.

Historical sites and artifacts are also important resources to protect. Keep your eyes out for artifacts as the excavation proceeds. Old disposal sites are often located along abandoned roads. Project planners should locate these sites and mark them to avoid disturbing the resource. If you find artifacts within the worksite, it is best to stop all work and notify the project inspector.

Road removal projects can often uncover refuse such as old culverts, logging cable, or other recently discarded garbage. Ask the project inspector what protocol they have for dealing with metal objects. One possibility includes placing refuse against the cut bank, smashing it down with the excavator bucket, and burying it under recontoured fill. State Parks' protocol stipulates that all refuse is gathered and hauled to a landfill or recycled.



Road removal projects may be necessary in many forest and vegetation types including clear-cuts, prairies, and old-growth forests. Left, a forest road traverses an old-growth redwood forest. Right, the same location just after a full recontour of the slope.

easily damaged and can slow tree growth and allow disease to enter the tree. Many road removal contracts include fines for striking and damaging “save” trees. While operating on private land, remember that damage to trees may reduce the timber value during a future harvest.

Projects in old-growth forests often begin after September 15 in order to protect endangered bird species. Because most road removal projects take many weeks to complete, the work season extends into the beginning of the rainy season. As the work season enters October it is important to watch weather forecasts and implement Best Management Practices to reduce the threat

Take precautions to prevent oil and fuel spills. Some contracts require that each piece of equipment have a spill response kit. These kits contain absorbent pads that can soak up spills and absorbent confinement tubes that can be used to stop spills from running down hills into streams. The spill kit also includes a five-gallon bucket that can be placed to catch a bad oil or fuel leak. If any leaks develop in hydraulic lines, stop work and make necessary repairs. Contracts with government agencies usually require that equipment be free of any fluid leaks. If spills occur that soak into the soil, it is necessary to place contaminated soil into bags, drums, or buckets and remove it from the project site. If large spills occur, alert the inspector to contact a spill response team immediately. Also, please remember to remove any oil buckets, grease canisters, or fuel drums from the site and dispose of them in a facility approved for the material type. If toxic materials from past land uses are discovered on a site, contact a qualified hazardous waste cleanup contractor.

To prevent erosion and sedimentation, do not push soil into active streams. Also, limit construction activities to dry weather conditions. When walking equipment into a site that has springs or seeps, attempt to keep the equipment footprint to a minimum. Avoid travel through wetlands or bogs.

SAFETY ON THE JOBSITE

Working in and around heavy equipment is a dangerous job, even for the safest crew. Add to that the hazard of operating on steep terrain and you have a very dangerous worksite. Experienced operators are excellent at maneuvering across steep slopes and knowing the limits of the equipment. However, roll-overs do happen, so take your time and work with caution in steep terrain. Remember that seat belts do save lives. The construction industry has countless stories of operators, not wearing their seat belt, thrown from the cab and crushed under the equipment. With today's roll-over protection structures an operator may roll a piece of equipment down a mountain and come out uninjured thanks to the seat belt. Inspectors on the ground should be cautious too. Trees falling, limbs flying, and the unpredictability of what the equipment will do add to the hazard for the inspector.



During road rehabilitation projects, never push or sidecast dirt into streams. Whenever possible, limit construction activities to dry weather conditions. If temporary stream crossings are necessary, use culverts and washed rock ballast to build the crossing.



Safety is priority number one on all heavy equipment projects. Keep in mind that people not used to being on your job site may be unaware of any dangers.



Experience has shown that an operator wearing a seat belt can do cartwheels down a slope in a small dozer and live to work another day. Experience has also shown that someone not wearing the seat belt can be thrown from the cab of a machine during a roll-over and be instantly crushed. So be carefull out there! (No problems at this site...Courtesy of RCAA)

Operators working in parks and recreation areas will often encounter tourists in closed areas. On State and Federal land, work areas are declared closed to the public by a legal closure notice. This closure requires that signs be placed at all access points and that public notices be placed at trailheads and visitor use areas. However, some tourists may ignore the closure and enter the work area. If you encounter any tourists in a work area, stop work immediately and contact the project inspector.

Communication and signals between the operator and the project inspector are extremely important. Take time to discuss

hand signals to help avoid accidents and to increase efficiency. Hand held radios also improve communication between the operator and the inspector. It is usually necessary to idle down the equipment to use radios because of the noise. Radios can be used to get an inspector's attention quickly if tourists suddenly appear on site or if the operator has questions about the work. For safety, a cellular phone, CB, and park radio should be on site at all times. State Parks' safety protocol requires a radio check with the park headquarters and use of a cell phone from the project site at least once each week.

Before work begins, develop a safety plan. The plan should identify the location of the nearest helipad with map coordinates to help guide helicopters in an emergency. The location of the nearest ranger station, hospital, fire station and telephones should also be included in the plan. On the first day of the project



Left, State Park's safety protocol requires that every vehicle has a first aid kit and fire extinguisher. Right, for safety, know the location of the nearest helipad and write down map coordinates to help guide helicopters in an emergency.



All equipment and vehicles should have an appropriately-sized fire extinguisher easily accessible and fire fighting hand tools should be on site. This dozer operated by a private contractor has a bright red shovel, axe, and fire extinguisher mounted on the rollover cage.

discuss the plan with everyone on the jobsite. If new operators come onto the job, be sure they are brought up-to-date on the safety plan. Be sure first aid kits, stretchers, and spine boards are located in at least one service vehicle onsite and fire extinguishers are fully charged and easy to access.

Keep dry leaves and twigs cleared from the radiator and other hot spots on equipment. Be sure the machine is turbo charged or has a spark arrestor. All equipment and vehicles should have an appropriately sized fire extinguisher easily accessible and fire fighting hand tools should be on site. Use earplugs or other ear protection while machines are operating. Also wear a hard hat any time you work around equipment or power tools. People working on the ground around equipment should wear high-visibility clothing such as an orange survey vest.



People working on the ground around equipment should wear high-visibility clothing such as an orange safety vest and a hard hat. Left, the inspector keeps a carefull eye on the equipment and surrounding area for safety hazards such as unauthorized personel, unstable soils, and sparks or smoke. Right, people working on the ground look for signs of a natural channel during a crossing excavation.

ADAPTIVE MANAGEMENT

Watershed rehabilitation and road removal are rapidly growing and evolving disciplines. New methods of analysis and treatment are being applied on many different landscapes throughout the west and elsewhere. Professionals with diverse educational and technical backgrounds are all contributing their individual experience, skill, and knowledge to the collective process. As each project presents its own challenges, we should take the opportunity to incorporate the principles of adaptive management into our work. Adaptive management allows us to continue the essential work of watershed rehabilitation while developing our skills and knowledge.

The steps to effective adaptive management are simple: act, observe, learn, adapt. The process repeats itself over and over. Begin by implementing your project with the best available information and planning. Seek the expertise of others who have implemented similar projects and incorporate their advice into your own plan. When your project is complete, observe the results. Make your observations repeatedly and over a period of time to document the performance of your treatments. The observations can be formal monitoring programs or simple field observations. Compare your follow-up observations to the techniques used at various sites to determine what worked and what did not. Finally, modify your techniques to improve the next project. Do not hesitate to discard techniques that have repeatedly failed.

Adaptive management should be applied to all aspects of your project no matter how big or small. Assessment, mapping, prescription development, equipment operation, mulching techniques, and even something as specific as the format for field notes can be improved through adaptive management. By incorporating these steps into each of your projects, the cost-effectiveness and quality of each project will continue to improve as your watershed is successfully rehabilitated.

WATERSHED COLLABORATION

Collaboration is an essential component of any watershed rehabilitation program. Typically, there are many stakeholders in a watershed, each having their own vision and priority for their land and the watershed as a whole. Although priorities for individual property owners may vary widely, it is rare to find someone who does not support a healthy watershed.

Get everyone involved in the watershed planning process from the start. It will establish good communication and headoff many conflicts that could arise as watershed rehabilitation plans are implemented. The collaborative process also allows watershed planners to incorporate the talents of many individuals, groups, and public agencies into the rehabilitation efforts. For example, a lumber company that continues to harvest timber in a watershed may contribute heavy equipment or operators to rehabilitation efforts. Similarly, a local geologist could assist neighboring property owners in assessing their roads or streams. By collaborating with all stakeholders in a watershed, it is possible to achieve watershed health while satisfying the needs of everyone within it.